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A CONTRIBUTION TO A MONOGRAPH OF THE EXTINCT
AMPHIBIA OF NORTH AMERICA. NEW FORMS
FROM THE CARBONIFEROUS

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In the course of an extended investigation of the extinct Amphibia of North America the writer has studied several forms from the Carboniferous which cannot be referred to any known species and they are here described as new. He has, so far, studied thirty-five species of the Carboniferous Amphibia of North America, all of which, with one or two exceptions, belong to the Branchiosauria and Microsauria. The Branchiosauria are represented by a single species. Of the Microsauria there has been an abundance of material available, thanks to the kind offices of Dr. Bashford Dean and Dr. Louis Hussakof of the American Museum, who very generously gave the writer the privilege of examining nearly a hundred of the specimens studied by Cope. There are already prepared some two hundred pages of manuscript and nearly sixty drawings toward the completion of a monograph of the extinct Amphibia of North America, but as the publication of this must be deferred until the remainder of the known North American and the European species have been studied, it is thought advisable to describe the following forms in advance, the more detailed treatment of the described forms being held for the monograph.

The extinct Amphibia of the North American Paleozoic present a variety of forms, of very diverse organization. The forms known range from very small creatures like *Micrerpeton caudatum*, less than two inches in length, to large forms like *Eryops megacephalus* Cope from the Permian of Texas, which probably attained a length of eight or ten feet. A rather interesting parallel can be drawn between the Paleozoic Amphibia and the reptiles of today. The snakes are represented in the Paleozoic by the limbless, snake-like Amphibia, such as *Ptyonius*, *Dolichosoma*, *Ophiderpeton* and *Molgophis* of North

America and Europe. The lizards find their counterpart in the Hylonomidae and the Tuditanidae. The turtles are represented by *Dissorophus* and its allies from the Texas Permian and the crocodilian aspect of the fauna is found in the large labyrinthodonts of the Permian, but more especially of the Triassic.

The Amphibia whose remains are found preserved in the Carboniferous rocks of North America all belong to the order Stegocephala, characterized by the completely roofed-over cranium and the great development of the parasphenoid. Five suborders of the Stegocephala may be recognized. These are: The Branchiosauria, The Microsauria, The Aistopoda, The Temnospondyli, and The Stereospondyli. All five of these suborders are represented in the Carboniferous of North America but it is our purpose here to examine only forms belonging to the first two suborders, i.e., the Branchiosauria and the Microsauria.

The Branchiosauria were salamander-like in form and were, for the most part, devoid of the heavy dermal armor of many of their contemporaries. They were naked, with the exception of small ovoid scales on the back and the chevron-shaped armature of the ventral surface which was almost universally present among the Carboniferous Stegocephala and may have been present in the Amphibia as late as the Laramie Cretaceous. The tail was rather long and flattened from side to side and the creatures were adapted for life in the water for at least the early part of their existence, as is shown by the possession of gills in many of the Permian and late Carboniferous forms of Europe. The group of the Branchiosauria are without doubt the direct ancestors of the modern salamanders and perhaps of the other groups as well. No branchiosaurian has ever been described from so low in the geological series as the one here given and it is the first evidence of the occurrence in North America of a group which was so abundant in Europe during the Permian.

MICRERPETON CAUDATUM gen. et sp. nov.

(Figs. 1-7)

The genus *Micrerpeton*, of which the single species is described below, is the only evidence of the occurrence of the Branchiosauria in North America, and as such is of unusual interest. There have

been three other genera referred to the Branchiosauria from the North American deposits but there is good evidence that none of them belongs here. The genus *Amphibamus* (Fig. 24) was originally referred to the Xenorhachia by Cope¹ on account of the supposed cartilaginous condition of the vertebrae and the absence of ribs. Later he abandoned this order and placed the form in the order Branchiosauria where it is retained by Zittel.² Recently Hay³ has shown, and I am able to corroborate his statement, that there are ribs present in the species *Amphibamus grandiceps* Cope, and that they are long and curved, not at all like the short ribs of the true Branchiosauria. These long, curved ribs unquestionably exclude the form from the Branchiosauria and indicate its close affinities with the Microsauria. The genus *Pelion* has also been referred to this group on purely negative evidence.⁴ The genus is excluded from the Branchiosauria by the well-ossified condition of the limb bones, in which the endochondral ossification is seen to be well developed, a condition which never prevailed among the Branchiosauria so far as is known. The form of the head and the elongated hind limb would also tend to exclude this form from the group. In the Branchiosauria the fore limb is usually larger than the hind limb, but in *Pelion lyelli* Wyman the hind limb greatly exceeds the fore limb in length. The genus *Sparodus* as it occurs in North America has also been referred to this group by Lambe.⁵ In the first place the presence of the genus *Sparodus* in the deposits of North America is so uncertain as to render consideration of the form almost unnecessary. The presence of the genus is indicated by remains which are almost impossible of definition and such a reference as made by Dawson is at the best an uncertain one.

The form, *Micrerpeton caudatum*, is represented by very complete remains (Pal. Coll., U. of C., No. 12,313). The specimen is preserved on opposite halves of a nodule from the Mazon Creek beds of Grundy County, Illinois. In a recent conference with Dr. David White

¹ *Proc. Acad. Natl. Sci. Phila.*, 1865, pp. 134-37.

² Zittel, *Handbuch der Paleon.*, 1 Abth., Bd. 3, p. 375.

³ *Proc. Amer. Phil. Soc.*, 1900, p. 120.

⁴ Zittel, *Handbuch der Paleon.*, 1 Abth., Bd. 3, p. 375.

⁵ *Trans. Roy. Soc. Canada*, 1904-5, Vol. X, p. 45.

he stated that the Mazon Creek beds are possibly to be placed somewhat lower than the Lower Kitanning, so that the deposits are in the lower part of the Allegheny series as they are now understood. The specimen was collected many years ago by Mr. W. F. E. Gurley at Mazon Creek but it has never been studied, although Dr. Newberry examined it and pronounced it to be amphibian and said in a note that Professor Cope should see it. Unfortunately Cope did not see it and it has lain unknown in the collection as unnoticed by students as if it were still in its old bed. I am indebted to Dr. Stuart Weller for calling my attention to the specimen and to him is due the interest which I have taken in the form.

The specimen (Fig. 1) is exceptionally perfect. Not only are nearly all of the skeletal elements present but the general contour of the body, the character of the dermal covering, the color-markings, the lateral line system, and many other features of interest have been detected. Such completeness of preservation is very uncommon even among the remains obtained from this locality. In this case the entire form was preserved but the collector in cracking the nodule lost the chips containing the hands and feet so that portions only of the limbs remain. It is thus impossible to determine the phalangeal formula, but the feet were probably like those of *Branchiosaurus amblystomus* Cred., as given by Credner, to which the present form is closely allied and indeed must be placed in the same family with *Branchiosaurus*, *Pelosaurus*, and *Melanerpeton*.

The remains here described represent a small salamander-like form, and they are the earliest geological evidence of the group, which without doubt gave rise to the modern salamanders. The parts preserved in the specimen are: the complete outline of the head with the cranial elements easily distinguishable and the black pigment of the iris; the entire vertebral column including pits in the tail region where the vertebrae were without doubt entirely cartilaginous; parts of the pectoral girdle; parts of the pelvic girdle; the humerus of the left side; the ventral scutellation; the ribs of one side of the body; and indications of ribs on the other; portions of both hind limbs and a complete impression of the fleshy tail. On this impression of the tail are preserved small horny scales, transverse color-markings, and distinct impressions of the lateral line system.

The bones of *Micrerpeton*, as in so many of the fossils from this locality, have been replaced by a white friable mineral which is

FIG. 1



FIG. 2

FIG. 1.—Impression of *Micrerpeton caudatum* on the Mazon Creek nodule. The median lateral line is distinct and evidences of the ventral scutellation may be seen on the upper side of the vertebral column. Two and one-third times natural size.

FIG. 2.—A photograph of the ventral scutellation of *Micrerpeton*. $\times 5$.

probably kaolin. The animal is preserved on its back and the photograph (Fig. 1) represents the ventral surface of the form. The entire length of the animal is only 49 mm of which the tail occupies nearly one-half.

The head has much the same shape as in the species of *Branchiosaurus*, figured by Fritsch and Credner. The eyes occupy relatively the same position as in that genus. The orbits are very large and are broadly oval. Within the borders of the rim the stone is blackened as though by the black pigment of the iris such as Cope has described in *Amphibamus*.¹ Under a rather high power of magnification the cranial bones are seen to be represented by mere flakes of white mineral matter. The sutures separating the cranial elements are distinctly preserved on the obverse of the main nodule and the description of the elements will be as they are there depicted.

The openings of the skull are five: the two orbits, the two minute nostrils and the pineal foramen. A median suture separates the skull into two equal halves and the pineal foramen lies slightly anterior to the posterior third of its length. The boundaries of the premaxillae are not distinct but they were very small elements and formed the inner border of the nostrils which are clearly indicated by bosses of stone. The nasal element is nearly square and lies anterior to the frontal which it borders broadly. The parietal is about the same size as the frontal and it apparently forms a portion of the inner border of the orbit although this is not an assured character. The parietal is elongate and unites posteriorly with the supraoccipital. The supraoccipital with the epiotic and the supratemporal (prosquamosal) form the posterior boundary of the skull and they are hence not unlike the same elements in other Stegocephala. The prefrontal forms the anterior border of the orbit. The lachrymal has not been detected. The maxilla is elongate and forms the antero-lateral border of the skull. No teeth nor impressions of teeth have been detected. The maxilla is elongate and forms the antero-lateral border of the cranium. The jugal forms an important element in the lateral border of the cranium and joins the quadratojugal posteriorly. The postfrontal is triangular and with the postorbital forms the posterior border of the orbit. Both of the elements are acuminate posteriorly although the

¹ *Proc. Acad. Natl. Sci. Phil.* 1865. p. 137.

suture between them is indistinct. They inclose between their posterior acuminations an interior projection of the squamosal. The squamosal has the usual relations and borders the supratemporal laterally. The latter element forms the quadrate angle of the cranium.

The entire length of the vertebral column is preserved although the nature and structure of its elements cannot be determined. The impressions of a few of the vertebrae show that some of the centra were amphicoelous but other than this nothing can be stated. The cavities which the centra occupied were filled by the white mineral matter and the force of the blow which cracked the nodule destroyed the form of the mold. It is possible that where the mineral matter has filled the cavities the centra were bony or partly so and where the cavities were unfilled the centra were entirely cartilaginous. The length of the vertebral column from the base of the skull to the last impression of a cartilaginous centrum is 33 mm.

The number of centra between the sacral vertebra and the skull is twenty (Fig. 5) as they are preserved but there may have been one more, the atlas. Fritsch has represented twenty-one in his restoration of *Branchiosaurus salamandroides* and this is further indication of an affinity between the two genera although Credner has represented twenty-six presacral vertebrae in *Branchiosaurus amblystomus*. The presacral vertebrae are thus seen to vary within narrow limits, but the number of presacrals is near twenty and this may be taken as typical. It is interesting to notice that in modern forms of the salamanders the presacral vertebrae are about twenty. The significance of this will be discussed elsewhere. There is but a single sacral centrum in *Micrerpeton*. The sacral rib has not been detected but it is restored after the condition given in *Branchiosaurus*. The right femur partially covers the sacral vertebra. Its structure cannot be determined. I count impressions of seventeen caudal centra of which at least twelve may have been partially ossified. In the cervical region there are distinct impressions of transverse processes on at least five vertebrae and this number is assigned to the neck although it is by no means certain that this is the correct number. The neck was at least short if we may judge from the position of the remains of the pectoral girdle. No cervical ribs are definitely determined. There is a short

rib lying between the fifth and sixth vertebrae but to which it belongs is uncertain.

There are impressions of ten ribs preserved on one side of the vertebral column and one on the other side. They are short, straight, and heavy as are the same elements in *Branchiosaurus*. This character alone is sufficient to place *Micrerpeton* among the Branchiosauria since no such ribs are known in other groups of the Stegocephala. The ribs preserved lie next the seventh to the seventeenth vertebrae on the left side and there is one on the right side which may belong to either the fifth or sixth vertebra. The ribs are central in their attachment and in this they agree well with the mode of rib attachment of the ribs in modern salamanders. All of the ribs are single headed and are composed, for the most part, of perichondral tissue. The position of the ribs in the matrix, inclined backwards and making a small angle with the vertebral column is very suggestive of the condition found in *Branchiosaurus*.

The pectoral girdle is represented by three distinct elements of the left side. They are identified as scapula, clavicle, and coracoid. This is the nomenclature given by Woodward although Credner would call them otherwise. The nomenclature and morphology of the elements of the pectoral girdle will be discussed fully elsewhere and is not necessary here. The scapula is represented by an ovoid fragment lying next to the vertebral column. The clavicle was probably spatulate as it is in *Melanerpeton* but the inner end of the element is not visible. The coracoid is represented by its outer end only and its inner pointed extremity is not visible. The interclavicle has not been detected.

The humerus lies somewhat to one side of the pectoral girdle as if there had been a large amount of articular cartilage. Its position may be due to post-mortem shifting but there is little other evidence of any movement after deposition. The humerus is a large heavy bone in comparison to the rest of the skeleton. It is expanded at each end and its ends show concavities proving that the bone is formed principally of perichondral tissue as would be expected from such an early Branchiosaurian. The endochondrium has not yet developed in this form which is evidently adult. There is no other element of the arm present.

Of the pelvis there is but a single element present. This is a slender elongate rod and it is undoubtedly the ilium since it has the usual position for that element and is much too large for a sacral rib. It has much the same shape as in the modern *Salamandra*. It is not

expanded as in the ilium of *Branchiosaurus*. This element, like the humerus, seems to have been but a hollow cylinder of bone and undoubtedly had cartilaginous ends as in the ilium of the recent *Salamandra*.

The two femora are preserved nearly entire. The right one lies upon and partly obscures the sacral vertebra. The femur is much more slender than is the humerus. It is but slightly expanded at the ends and like the humerus shows the concavities at the ends indicative of the perichondral character of the tissue composing it. The

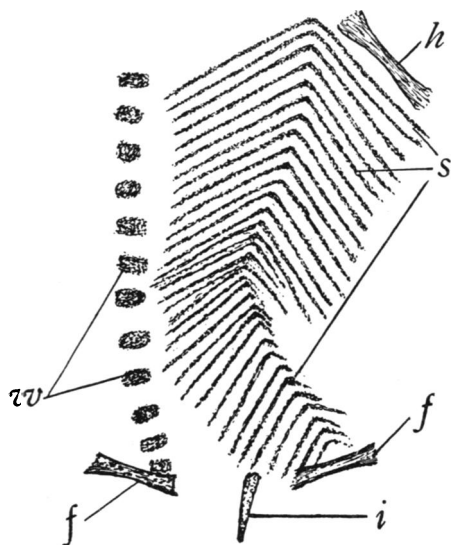


FIG. 3.—Ventral scutellation of *Micrerpeton caudatum*. F=femur; H=humerus; I=ilium; S=the lines of scutes; V=the vertebral column. $\times 5$.

endochondral tissue is a later development and finds its first expression late in the embryonic and phylogenetic development of the vertebrates. Of the leg there are two elements preserved more or less entire (Fig. 5). These are the tibia and the fibula. The larger one may represent the tibia and the smaller one the fibula. They both present characters similar to those of the femur and the humerus. They are both rods of bone tapering at the distal end. The feet have been lost, though doubtless at one time present.

The ventral surface of the body, as in other members of the Branchiosauria, was covered and protected by a series of small scutes arranged in the regular chevron pattern (Figs. 2, 3). The form of the scutes and their number cannot be determined. The

lines which represent them are, however, distinct. A portion of the scutes are missing and part of them are obscured by lying over the vertebral column. They are all somewhat shifted to the left. The lines are very small and close together. I count sixteen of them in a distance of two millimeters. In length the longest line preserved is a little more than four millimeters, measuring from the point of the chevron. The lines representing the scutes came to a point in a median ridge which is now represented by a line. The dermal scutes on the abdomen were probably the forerunners of the abdominal ribs of the reptiles.

The impression of the tail contains some of the most interesting features in the entire specimen. Scattered over it and in places laid in a mosaic are impressions of small dermal scales which may have covered the entire body. In form the scales are ovoid, being half as wide as long (Fig. 6). The markings on the scales partake of the nature of radiating lines much after the pattern of the sculpturing of the cranial bones in many of the Microsaurial and later forms. The scales are less than one-half a millimeter in diameter and their character

can only be ascertained under high magnification. Near the middle part of the tail there are preserved distinct transverse bands of a dark color (Fig. 4). These markings are more or less evident throughout the entire tail impression but they are elsewhere not so distinct as in the central region. The lines are evidently due to rows of pigmented scales and in all probability the animal's entire body was transversely striped.

The most interesting and important single structure discovered on

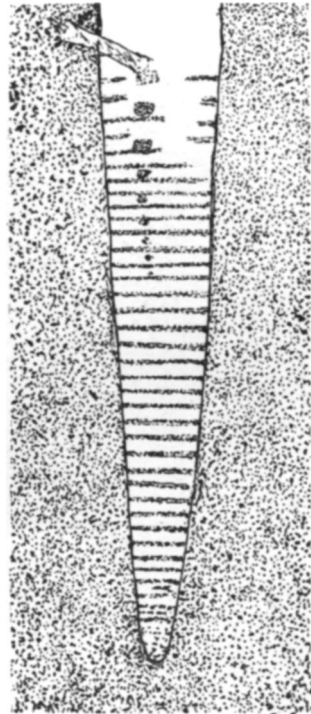


FIG. 4.—The banded color-markings on the tail of *Micrerpeton*. $\times 5$.

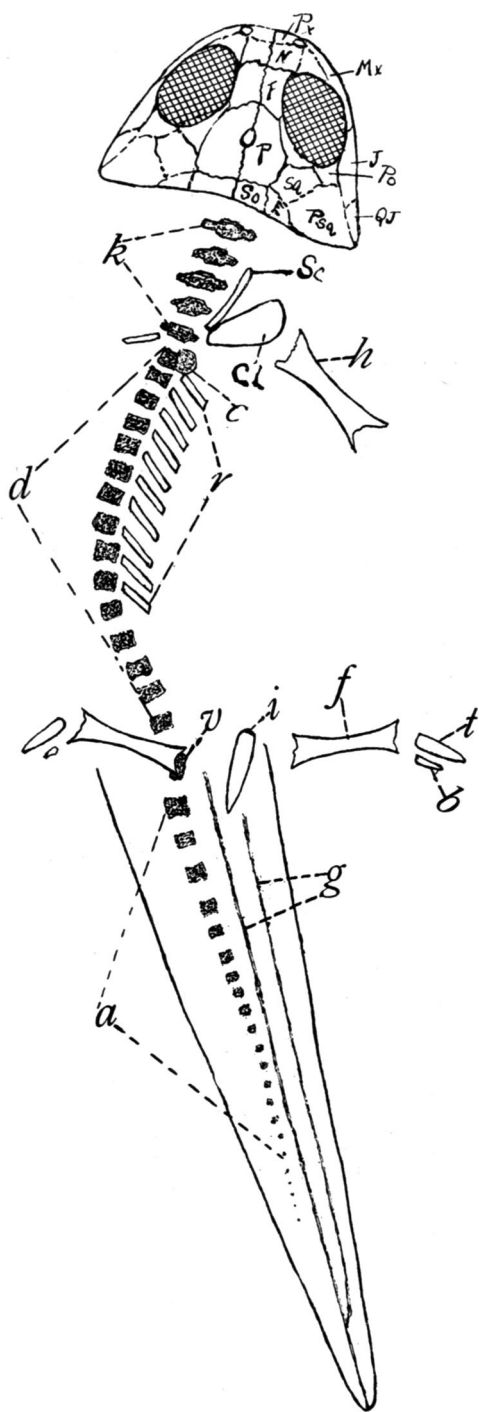


FIG. 5.—The skeletal elements of *Micrerpeton caudatum*, as preserved. E = epiotic; F = frontal; J = jugal; M = maxilla; N = nasal; P = parietal; Po = postorbital; Px = premaxilla; Qj = quadratojugal; Psq = supratemporal; So = supraoccipital; a = caudal vertebrae; b = fibula; sc = scapula; d = dorsal vertebrae; f = fibula; g = lateral line; i = ilium; k = cervical vertebrae; r = ribs; t = tibia; cl = clavicle; v = sacral vertebra; c = coracoid (?). X 5.

the specimen is the impression of the lateral line system, which is clearly evident as two dark lines on the impression of the fleshy part of the tail. The sense organs are represented by two longitudinal rows of pigmented scales, one beginning at the tip of the tail, the other

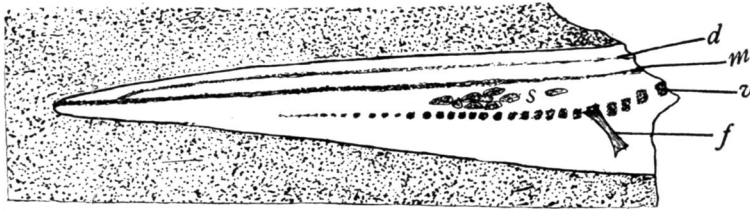


FIG. 6.—Impression of the tail of *Micrerpeton caudatum* showing the arrangement of the lateral line sense organs and the position of the vertebral column. D=dorsal lateral line; M=median lateral line; F=femur; S=scales; V=vertebral column. $\times 5$.

taking its origin from the median line somewhat further forward. I am indebted to Dr. K. Takahashi for calling my attention to the similarity of this arrangement to that found in the modern *Necturus*. The arrangement and disposition of the lines containing the sense

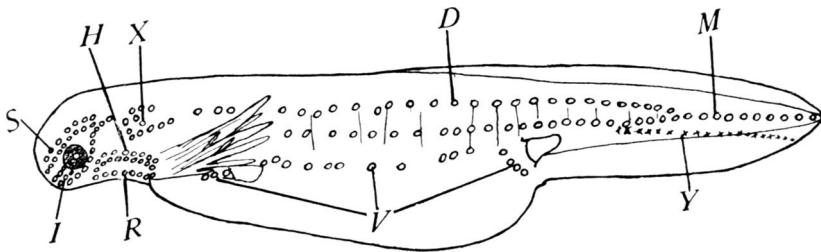


FIG. 7.—Outline of a young larva of *Necturus* showing the position of the lateral line system. D=dorsal lateral line; H=hyomandibular sense organs; I=infraorbital sense organs; M=median lateral line; R=mandibular sense organs; V=ventral lateral line; X=sense organs supplied by branches from the glossopharyngeal and vagus nerves; Y=the position of the vertebral column. Modified after Platt. Enlarged.

organs is practically the same in the two forms (Figs. 6, 7). The median lateral line takes its origin from the extreme tip of the tail and is continued to the base where the impression is broken. The dorsal lateral line has its origin rather abruptly from the median lateral line at a distance of six millimeters from the tip of the tail. The

sense organs were undoubtedly located beneath specialized pigmented scales on the surface of the animal's body and to this pigment is due the preservation of the lines.

The fact that the arrangement of the sense organs of *Micrerpeton* corresponds so exactly to the condition found in *Necturus* is of considerable interest. *Necturus* alone among the modern tailed Amphibia has the arrangement above described for the lateral line system in *Micrerpeton*. All other forms of the Caudata as also the larval forms of the Salientia have an arrangement of the lateral line system which is perfectly distinct from that found in *Necturus*, although the basal arrangement is the same in nearly all forms. In *Ambystoma*, for instance, the median lateral line is not present on the tail and the dorsal line is but incompletely developed. The close similarity of the arrangement of the systems of sense organs in the two forms, *Micrerpeton* and *Necturus*, may be of genetic significance with regard to the latter form. The lateral line sense organs are of a very fundamental significance and it is not at all improbable that the same arrangement of the lines has existed from the Carboniferous times down to the present. We know that such has been the case in a great many of the fishes. The ancestors of the modern Caudata must have originated somewhere in the Carboniferous or earlier periods and it is the opinion of the writer that the Branchiosauria represent the direct ancestral forms for this group of the modern Amphibia. This suggestion is by no means new, since Baur and others have held the same view. The writer hopes to present a fuller discussion of this topic at some future time.

The relations of the form *Micrerpeton caudatum* are readily determined. The number of the presacral vertebrae, the form and position of the ribs, the shape of the skull, the arrangement of the cranial elements, the structure of the pectoral girdle, and the character of the ventral armature all clearly bespeak a close relationship with *Branchiosaurus*, *Melanerpeton*, and *Pelosaurus* from the Lower Permian and Upper Carboniferous of Europe. The distinction of the genus *Micrerpeton* from the other known branchiosaurian genera is found in the apparent absence of sclerotic plates, the shape of the skull, the arrangement of the cranial elements and the form of the ilium.

So far as I am aware the species above described is the earliest geological evidence of the Branchiosauria since the earliest forms known from Europe are from the Stephanian (Upper Carboniferous). The species is also the only true branchiosaurian known from North America as stated above. The presence of this form in America is of considerable interest in the bearing it has on the distribution and migration of the Paleozoic animals. It is a great distance from Europe where the other Branchiosauria are found, to America and it must have taken an immense length of time for such slow-moving creatures as the Amphibia to have migrated this distance. Whether the migration took place after the development of the branchiosaurian type or whether the type was evolved in the two places is an open question and must be settled by future research. It is possible that it was the piscian ancestors of the Amphibia which migrated across the seas and began the amphibian phase of their development independently in the two continents.

MEASUREMENTS OF THE SPECIMEN OF *Micrerpeton caudatum* MOODIE

	mm
Entire length of animal.....	49
Length of head in median line.....	6.5
Width of head at posterior border.....	8
Length of orbit.....	2.5
Width of orbit.....	2
Interorbital space.....	2
Length of vertebral column.....	33
Length of single vertebra in dorsal series.....	0.5
Length of trunk from base of skull to sacrum.....	22
Length of rib.....	1.5
Length of scapula.....	3
Width of clavicle, maximum.....	2
Length of humerus.....	2.5
Length of ilium.....	1.5
Length of femur.....	2
Length of tibia.....	1.5
Length of tail impression.....	21.5
Width of tail impression at base.....	4

The Microsauria are represented in the Carboniferous of North America by numerous forms usually with well-developed dermal plates and almost always with the ventral scutellation. They ranged

in size from the small *Tuditanus minimus* from the Cannelton slates of Pennsylvania, three or four inches in length, to forms like *Diplocaulus* and possibly *Macrerpeton* which without much doubt reached a length of several feet. All the members of this suborder had well-developed cranial elements which are usually ornamented with radiating grooves or with pits. The pectoral arch is well developed and is composed of dermal elements which are ornamented with sculpturing similar to that of the cranial bones. The body of these animals was in a few cases covered with overlapping scales, but others appear to have had only the ventral surface armed and this was in some cases especially strong as in the genera *Saurerpeton* and *Sauroplorea*. The vertebrae are uniformly of the phyllospondylous type. This is so generally the case that the condition of the vertebrae is taken as one of the chief characters of the group. Various peculiarities are seen among the Microsauria in the development of horn-like projections on the skull in genera which are in no way genetically related. The Microsauria continued on into the Permian in the family Diplocaulidae.

The genus *Tuditanus* is represented by several species in the Carboniferous rocks of North America. Eight species are associated provisionally under this genus. Six of them were described by Cope from the Linton deposits of Ohio and two are described herewith from the Cannelton slates of Pennsylvania. A discussion of only three of the species will be given here since little of interest has been obtained from the study of the other species. The three forms here discussed are *Tuditanus tabulatus* Cope, *T. minimus* sp. nov., and *T. sculptilis* sp. nov. The facts which make the first-named species of interest here are the discovery of the lateral line canals on the skull and the correction of several errors in the original description as given by Cope.

TUDITANUS TABULATUS Cope.

(Figs. 8, 9)

The species is known from a single well-preserved skull and its obverse in the collection of the Columbia University of New York City. I am indebted to Dr. Bashford Dean for the privilege of studying this interesting form. It is from the Linton deposits of Ohio.

The remains include a nearly complete cranium and a complete clavicle of the right side. The species agrees in all essential respects with the characters of the genus *Tuditatus*, presenting a broad, flat head, and a triangular thoracic shield.

The cranium is wider than long and the muzzle is broadly rounded (Fig. 8). The orbits are wide ovals, and their posterior borders fall little behind the transverse line dividing the skull equally. The inter-orbital width equals the longitudinal diameter of the orbit. The posterior outline of the cranium is truncate in a straight transverse line between the prominent epiotic angles. The composition of the cranium is different from any of the other species referred to this genus in the large size of the epiotic and the fact that the squamosal is excluded from the parietal by the extension of the postorbitals and the epiotics. This



FIG. 8.—The skull and right clavicle of *Tuditatus tabulatus* Cope. One and one-half times natural size.

may be a generic character and entitle the form to another name but it is retained here for the present. The elements of the anterior part of the skull are not preserved but they are indicated by the broken lines. The nostrils are, however, clearly indicated as bosses of shale. There is a mere fragment of the nasal preserved posterior to the crack indicated by the transverse line (Fig. 9). The frontal is elongate as in other species of the genus and forms the inner border of the orbit. The parietal, as usual, is one of the larger bones of the skull roof and the pineal foramen is inclosed in the median suture by the two parietal elements. The parietal opening lies in

the posterior half of the parietal. The supraoccipital is almost square being slightly elongate transversely. It unites laterally with the epiotics with which it forms the truncate table of the skull. The suture separating the epiotic from the squamosal is clearly distinct. Although such a position for the squamosal is unusual it is not unique since the same character has been observed in *Diceratosaurus laevis* to be described later. The postfrontal is rather small and it together with the postorbital forms the posterior boundary of the orbit. The postorbital is truncate posteriorly and joins the epiotic broadly. The squamosal lies posterior to the postorbital and jugal and borders the quadratojugal which is an unusual condition but what significance the condition has remains to be determined. Posterior to the squamosal lies the supratemporal which forms the quadrate angle of the cranium. The quadratojugal is a small element and forms a part of the lateral boundary of the skull. The jugal is a large element and forms the entire lateral border of the orbit. There are no teeth preserved on the fragment of a maxilla but there are some impressions farther forward which resemble the pleurodont denticles of the modern Amphibia.

The sculpture of the surface of the cranium consists of parallel ridges which are separated by grooves equal to them in width. The ridges radiate inward on the squamosals and frontals and outward on the supratemporals. They are somewhat interrupted on the other skull elements. The lateral thoracic shield, which represents the right clavicle, is ornamented with a similar sculpturing of uninterrupted radiating ridges. Cope described an atlas in connection with this skull but I do not find it. The slender impressions to the right of the pectoral shield may possibly represent ribs. They are gently curved and truncate at the inner end.

A nearly complete system of lateral line canals has been detected on this skull (Fig. 9). The canals preserved are: the temporal, the jugal, the infraorbital, the occipital cross-commissure and the supra-orbital. The nomenclature of the canals is that adopted in a contribution on the sensory canals in the extinct Amphibia now in press. The occipital cross-commissure is represented by a row of elongate pits such as Andrews¹ has described for *Ceraterpeton galvani* Huxley

¹ *Geol. Mag.*, Dec. IV, Vol. II, p. 81.

from the Coal-measures of England. The cross-commissure is contained within the epiotics. The jugal and the temporal canals form a complete ring much as the same canals do in *Trematosaurus*. The squamosal in *T. tabulatus* is excluded from the parietal by the extension of the epiotic and the postorbital and it is to be noticed that the temporal canal has a changed position to correspond with the changed condition of the squamosal. This is of considerable interest in connection with the correlation of the squamosal in fishes and amphibians. This subject has been fully treated in another place, and it will only be necessary here to state that on the basis of the lateral line canals and their arrangement in the fishes and the Amphibia the true correlation of the squamosal element in amphibians and fishes has been made. This contradicts the results obtained by Thyng¹ from embryological studies. Thyng's results are noticed more fully in the paper

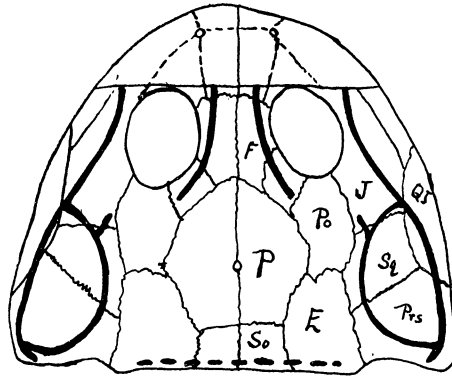


FIG. 9.—The outline of the cranial elements and the lateral line canals in *Tuditanus tabulatus* Cope. One and one-half times natural size.

above cited. The temporal canal has apparently an indication of a connection with the supraorbital canal but of this I am not sure. The jugal canal occurs on the supratemporal, quadratojugal, and it joins the infraorbital on the jugal. The infraorbital is indicated by a short portion some few millimeters long under the orbit and the rest, i.e., its connection with the jugal canal, is restored. There is nothing unusual to be observed in that portion of the infraorbital canal which is preserved. The supraorbital canal is indicated by a curved, broad, shallow groove on the inner side of each orbit. As above stated there seems to be a connection between this canal and the temporal but I am not sure. The primitive conditions shown in the lateral line canals in *T. tabulatus* are the presence of the occi-

¹ "Tufts College Studies," 1906, Vol. II, No. 2.

pital cross-commissure and the ring-like formation of the temporal and jugal canals which is too clearly indicated to be overlooked.

MEASUREMENTS OF THE TYPE OF *Tuditanus tabulatus* COPE

	mm
Median length of the skull.....	29
Width of skull at posterior border, estimated.....	37
Width between epiotic angles.....	18
Length of orbit.....	8
Width of orbit.....	6 5
Diameter of nostril less than.....	1
Diameter of pineal foramen less than.....	1
Length of right clavicle.....	13
Width of right clavicle.....	5.5

The specimen with its obverse representing this species is from Linton, Ohio. It formed a part of the collection of Dr. J. S. Newberry and is now in the Zoölogical Collection of Columbia University, New York City.

TUDITANUS MINIMUS sp. nov.

(Fig. 10)

The form represented by the above-named species is preserved on one side of a slab of slate, belly downward, from Cannelton, Pennsylvania. The obverse slab has been lost, which is very unfortunate, since there is no doubt that the entire skeleton was preserved. The species is placed in the genus *Tuditanus* on account of the close resemblance to the type form *T. punctulatus* Cope, although it is much smaller than that species. It is in fact the smallest of the Microsauria which the writer has thus far studied.

Tuditanus minimus, as the name implies, is not only the smallest member of the genus but of the suborder as well, as has just been stated. It did not attain a total length of more than three and one-half inches. Its form is very lizard-like but its structure is typically stegocephalan. The form of the skull is especially similar to that of the type species *T. punctulatus* which it resembles in the narrow posterior truncation of the skull, as well as in the anterior position of the orbits.

The skull is in the form of a narrow oval, sharply narrowed posteriorly and truncate. The orbits are located well forward and their

posterior border lies in front of the line dividing the skull transversely into equal parts. The interorbital space is greater than the diameter of the orbit. Impressions of teeth are preserved on the premaxillae and maxillae (Fig. 10). There are eight of them in a distance of three millimeters. The teeth appear to be mere blunt denticles and were possibly pleurodont.

The elements of the cranium are very poorly preserved. It has been impossible to determine all of the sutures. The bones of the premaxillary region have been destroyed but the arrangement of them was probably not far different from that which obtains in other members of the genus. The posterior boundaries of the nasals are preserved and prove this element to have had an obtuse posterior border. The sutures bounding the frontals are clear and show that they were small and that they formed a part of the inner boundary of the orbits. The parietal is recognized as a large element, apparently the largest in the

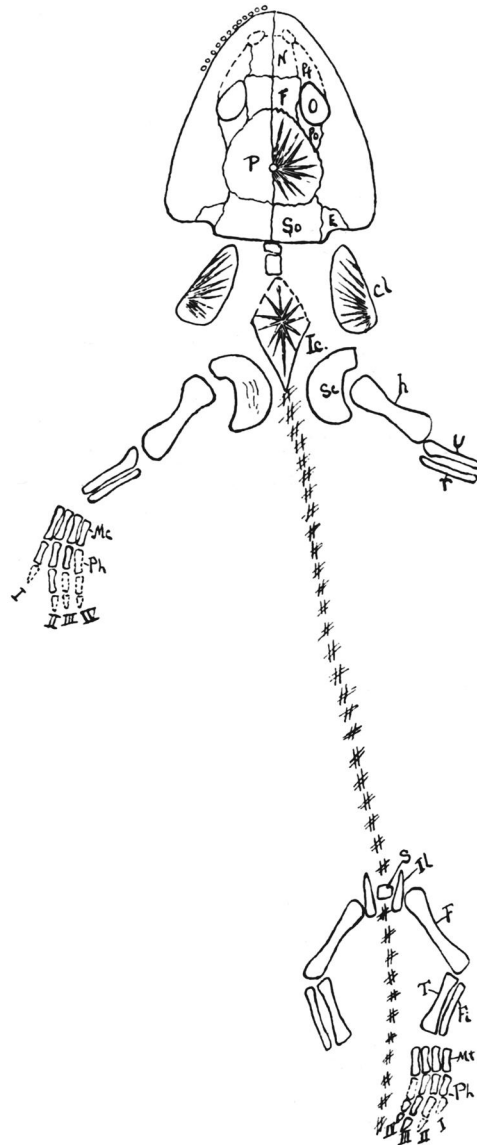


FIG. 10.—The skeleton of *Tuditanus minimus* as it is preserved on the black slate. The lettering as in figure 5. $\times 2$.

skull. Together the parietals form a wide oval inclosing on the median suture the circular pineal foramen. The parietals are sculptured with coarse radiating grooves and ridges much after the manner of *T. radiatus*. The pittings present on that form are, however, absent here. The sutures bounding the supraoccipital are tolerably well assured and these show that element to have been rather large, quadrate and with the usual relations for the element. The epiotic is distinct. It is triangular and small. It is produced into an angle on the posterior border strongly recalling a similar condition in *T. punctulatus* Cope. The boundaries of the prefrontals and the upper borders of the maxillae are not clearly ascertained. They may have had the outline indicated (Fig. 11). The lachrymal has not been detected. The postfrontal and postorbital form the posterior boundary of the orbit although the limits of the latter element have not been definitely ascertained. The position of the squamosal is well assured, although its entire boundaries are not determined. It has the usual relations of the squamosal and joins the parietal broadly. The jugal is broad and widens posteriorly to abut on the supratemporal which, as usual, forms the quadrate angle of the skull. The sutures bounding the quadratojugal and the posterior end of the maxilla are not determined.

There are but two fragmentary vertebrae preserved and an estimate based on the length of these remains gives about thirty presacral vertebrae. The structure of the vertebrae preserved cannot be ascertained but the neural spines appear to have been low and stout.

There are six elements of the pectoral girdle preserved. These are: the two clavicles, the interclavicle, the coracoid of one side and the scapulae. The interclavicle is rhomboid in form and acuminate posteriorly. It is sculptured with radiating grooves and ridges. The interclavicle is different from the same element in *T. punctulatus* Cope in that the base is acuminate, not truncate, as in the latter form. The clavicles present much the same shape as does that element in *T. tabulatus* Cope. It is ornamented by a sculpturing of radiating lines which take their origin from the lower external angle as the bone lies in the matrix. The clavicle is somewhat triangular in shape and lies close to the skull, but this close approximation of the pectoral elements to the cranium is due probably to post-mortem shifting since

the scapulae are shifted as far backward. There can be little doubt however that the pectoral arch was not far removed from the cranium. There is an oval fragment preserved on the left of the specimen which I take to be a portion of the coracoid. The scapula is preserved entire on the left side and it is represented by fragments on the right side. It is almost semicircular in form and narrows externally until it is somewhat fan-shaped. There appears to be an ornamentation of lines on the surface of the bone. These lines follow the contour of the anterior border.

The forearm is represented nearly complete on the left side and the right side shows the humerus and the forearm. The humeri are unusual in that they have well-developed articular ends as though the development of the endochondral tissue was well developed in the form. The humerus is expanded at the ends and it is larger at the upper than at the lower end. The ulna is expanded at the proximal but is more attenuated at the distal portion. It is shorter than the humerus by about one-third of its own length. The radius is a mere slender rod of bone and presents the well-developed articular ends. It is slightly shorter than the ulna. The carpus is unossified and its position is represented by a blank space. There are phalanges of four digits preserved and this, apparently, represents the entire number of digits. There is one digit, the second, which has all of the phalanges preserved and they are four in number. The phalangeal elements like the other bones of the extremity have the articular surfaces prominent. The terminal phalanx is claw-like.

There are no ribs nor traces of them preserved and a conjecture as to their character cannot be hazarded since they are known in but two other species, in which they are curved. There is no evidence of a ventral scutellation and so far as is at present known this structure is absent from all of the species of the genus or at least it is but weakly developed. It is not present in the well-preserved *T. sculptilis* described below.

Of the pelvis the ilium alone is represented. The bone itself has disappeared and has left a depression which shows this element to have been an elongate rod very similar to that described for *Micrerpeton*. The sacral vertebra seems to be indicated by a depression between the iliac depressions.

One hind limb is preserved nearly entire and the greater part of the other is also preserved although the phalangeal elements are somewhat disturbed. The femur is slender and more elongate than the humerus. It has well-formed, rounded, articular ends. The tibia presents unusual characters in that its ends are truncate as though the cartilage composing its articular surfaces was not so highly calcified as in the other limb bones. It is somewhat expanded at the ends and is throughout its length broader than the femur. The fibula like the tibia is a slender rod of bone although it is somewhat shorter than is that element. The tarsus is unossified and its position is occupied by a blank space. Portions of both feet are preserved, but only one digit in the right foot is complete. The elements of the other digits are restored. The metatarsals are elongate and slightly expanded at the ends. There are four phalanges present in the complete digit which may represent the third but more possibly the fourth, and the first digit is wanting. The only terminal phalanx preserved is claw-like.

MEASUREMENTS OF *Tuditanus minimus* MOODIE

	mm
Median length of skull.....	15
Width of skull at posterior border.....	16
Length of orbit.....	3.5
Width of orbit.....	2
Interorbital width.....	2.5
Length of clavicle.....	6
Width of clavicle, maximum.....	3.5
Length of interclavicle, estimated.....	5
Width of interclavicle.....	3.5
Length of scapula.....	3.5
Width of scapula, maximum.....	2.5
Length of coracoid (?).....	2
Length of humerus.....	4
Length of radius and ulna.....	3
Length of metacarpal.....	1
Length of ilium.....	2.5
Length of femur.....	4.5
Length of tibia and fibula.....	3
Length of foot.....	3.5
Length of metatarsal.....	.75

The specimen is from the Cannelton slates, Middle Kitanning, near Cannelton, Pennsylvania. It is No. 4,555 of the U. S. National Museum Collection.

TUDITANUS SCULPTILIS sp. nov.

(Figs. 11, 12)

There is preserved in the collections of Walker Museum a small amphibian skull pressed flat on a slab of slate from Cannelton, Penn-

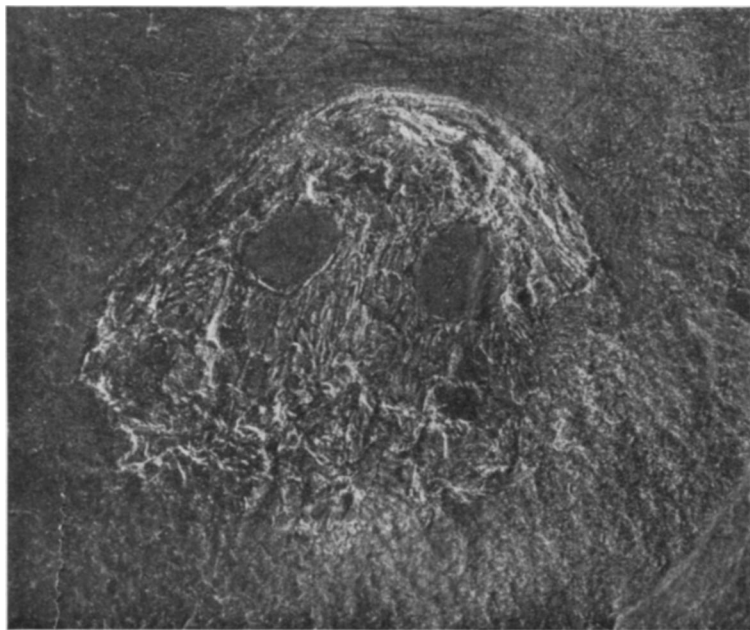


FIG. 11.—The skull of *Tuditanus sculptilis* as it is preserved on the slate. $\times 3$.

sylvania. This specimen formed a part of the Hall Collection recently acquired by the University of Chicago. It is No. 12,315, U. of C.

The specimen presents only a portion of the skull and fragmentary pectoral plates. The skull is wider than long and the muzzle is broadly rounded. The orbits are narrow ovals and their posterior border falls on the transverse line dividing the skull equally. The interorbital width is slightly greater than the width of the orbits and about equal to their length. The posterior outline of the skull is

somewhat truncate as in *T. tabulatus* Cope and other species of the genus. The distal extremities of the quadrates do not project as far backward as do the supraoccipitals. The skull roof is formed of the regular elements except that a quadrate seems to be indicated by a scale of bone on the posterior angle. The nostrils are oval and the pineal foramen is small.

The premaxilla is probably a relatively large element though its boundaries are not definite. The nasal is of an oblong shape and

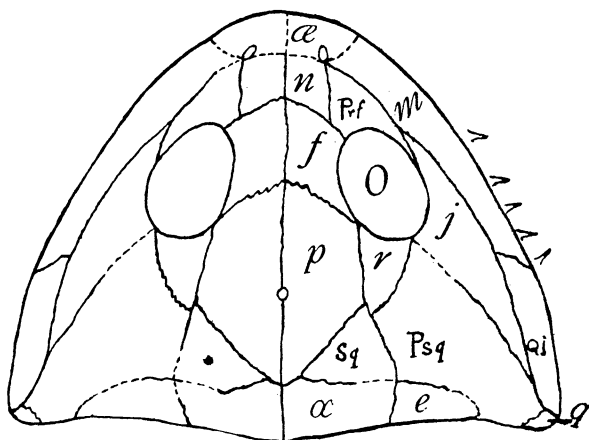


FIG. 12.—The elements of the cranium of *Tuditanus sculptilis*. Ae=premaxilla; e=epiotic; f=frontal; j=jugal; m=maxilla; n=nasal; O=orbit; p=parietal; q=quadrate; qj=quadratojugal; Psq=supratemporal; r=postfrontal; sq=squamosal; prf.=prefrontal.

borders the frontal anteriorly. The frontal forms the whole of the interior border of the orbit and borders the parietal broadly behind. The parietal is a large element and the pineal foramen is inclosed in the median suture about midway of the parietals. The supraoccipital is wider than long and with the epiotic forms the greater part of the posterior border of the skull. The prefrontal apparently forms the entire anterior border of the orbit and sends an acuminate projection to the side of it. The maxilla is excluded from the orbit and is an elongate element with sharp conical teeth of which there are four preserved. These measure about one millimeter in length. The jugal lies along the lateral border of the orbit and it is acuminate both anteriorly and posteriorly. It borders the supratemporal

broadly. The postorbital has not been detected. The postfrontal forms the greater part of the posterior boundary of the orbit. It is triangular and acuminate behind. It is bordered broadly by the parietal and supratemporal. The squamosal element is also triangular and it borders the parietal broadly. The supratemporal is evidently the largest element in the skull and on its posterior corner there is a flake of bone which may represent the quadrate though this is by no means certain. The quadrate has not been detected in any of the Carboniferous Microsauria so far studied although it is well developed in the Permian microsaurian, *Diplocaulus*. The epiotic is an elongate element in the transverse line of the skull. Its entire boundary is uncertain though a part of the sutures are present. The quadratojugal is elongate and lies posterior to the maxilla and with that element forms the lateral border of the skull.

The canals of the lateral line system have not been detected on the skull. The sculpturing of the cranial elements consists of grooves and ridges which radiate from a center. They are more prominent on the parietals than elsewhere although the other skull elements present a strong sculpturing.

There are also preserved on the slab of slate about ten millimeters posterior to the skull fragments of pectoral plates, probably representing the clavicles and interclavicle. They are so badly fractured that the form cannot be determined. No limbs or vertebrae have been observed.

MEASUREMENTS OF THE SKULL OF *Tuditanus sculptilis* MOODIE

	mm
Length of the skull in median line.....	20
Width of skull at posterior border, estimated.....	24
Diameter of orbit.....	3
Length of orbit.....	4
Interorbital space.....	4
Diameter of nostril, less than.....	1
Pineal foramen about one-half mm in diameter.	

DICERATOSAURUS LAEVIS sp. nov.

(Figs. 13, 14)

The genus *Diceratosaurus* was established by Jaekel¹ for the reception of the species described by Cope as *Ceraterpeton punctoline-*

¹ *Neues Jahr. Mineral.* 1903, p. 112.

atum from the deposits of Linton, Ohio. There are good evidences that the species does not belong in the genus *Ceraterpeton* and Jaekel's genus will undoubtedly stand. There are now known three species of this group, two of which are described herewith.



FIG. 13—The skull of *Diceratosaurus laevis* $\times 2$.

The species *Diceratosaurus laevis* is represented by an almost perfect skull (Fig. 13) in the American Museum collection. It is from the mines at Linton, Ohio and had been identified by Cope as *Tuditatus radiatus*. The specimen consists of the bones of the cranial roof, the bones themselves having disappeared. It is not probable that the skull bones were smooth. The details in the structure of the skull have all been ascertained quite definitely, and there can be no doubt that the arrangement of the cranial elements as shown

in Fig. 14 is accurate. As in *Tuditonus tabulatus* Cope the squamosal is excluded from the parietal.

The form of the skull at once recalls that of the species *D. punctolineatus* Cope as figured by Jaekel. The orbits are located in nearly the same region of the skull and the sutures separating the cranial elements are quite similar in the anterior region of the skull. The species *D. laevis* is based on the divergent character of the horn-like protuberances which project from the supratemporals. The horns of *D. punctolineatus* Cope are convergent. The present skull is also smaller and the parietals in *D. laevis* are much larger than in the type species. In the type species also the pineal foramen is located well forward in the parietal while in the present form the foramen is located well posterior.

The skull is almost rectangular. The nostrils are elongate ovals. The orbits are circular and the distance between them is equal to two-thirds of the dimension of the orbit. They are located well forward in the skull and are bounded laterally by the maxillaries. The parietal foramen is situated in the posterior third of the parietals. The nostrils have much the same character as in the type form. They are broadly oval.

The premaxillae are elongate transversely being about twice as long as wide. They are identical in shape and relations with the same elements in *D. punctolineatus* Cope. The nasal is nearly square and forms the interior boundary of the nostril. The frontal is elongate in the median length of the skull and it is acuminate posteriorly where the acumination is inclosed by the parietal and postfrontal. The parietals are by far the largest elements in the cranium. They form together an oval which is elongate in the longitudinal diameter of the

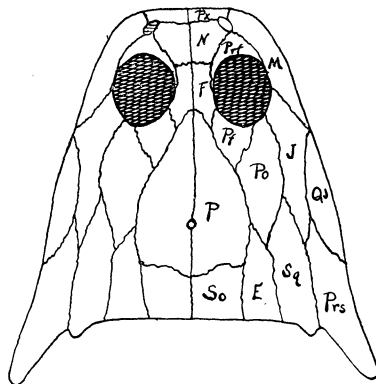


FIG. 14.—The elements of the cranium of *Diceratosaurus laevis*. E = epiotic; F = frontal; J = jugal; M = maxilla; N = nasal; P = parietal; Pf = postfrontal; Prf = prefrontal; Po = postorbital; Prs = supratemporal; Px = premaxilla; Qj = quadratojugal; So = supraoccipital; Sq = squamosal. $\times 1$.

skull. They inclose between them in the median suture the small pineal foramen. They are acuminate in front with a broad truncate posterior base where they are bounded by the supraoccipitals. The supraoccipital is nearly square, being somewhat wider than long. It joins the epiotic and the parietal. The epiotic is elongate in the longitudinal diameter of the skull. It ends anteriorly in a point which is inserted between the postorbital and the parietal. The epiotic bears a short protuberance posteriorly much as does the same element in the type species. There are four elements which take part in the formation of the posterior border of the skull. These are: the supraoccipital, the epiotic, the squamosal and the supratemporal. It is very unusual for the squamosal to reach the posterior edge of the cranium. The prefrontal lies anterior to the orbit of which it forms the anterior border. It has the usual relations. The lachrymal has not been detected although Jaekel¹ has identified it in his drawing of the skull of the type species. The maxilla is elongate and forms the lateral border of the skull. No teeth have been detected although they were doubtless the same as Jaekel has figured in *D. punctolineatus* Cope. The jugal is an elongate element joining the maxilla posteriorly. Jaekel included this element in his "perisquamosal" but the sutures are clearly evident in this specimen and no "perisquamosal" has been identified. The postorbital is fully as large as the jugal which it joins. It forms a part of the posterior border of the orbit and it ends posteriorly in a point which is inclosed by the epiotic and the squamosal. The postfrontal with the foregoing element forms the entire posterior border of the orbit and it likewise ends in a point inclosed by the parietal and the postorbital. The quadratojugal has much the same shape and relations as in *D. punctolineatus* Cope, although it is located farther back. The squamosal is also elongate as are most of the posterior cranial elements and it likewise has an acumination which is directed forward and is inclosed by the postorbital and the jugal. The squamosal abuts onto the posterior border of the skull. The anterior suture of the supratemporal element is rather indistinct but it is, I believe, as represented. The element is elongate and is prolonged posteriorly to form the horn, which ends in a blunt point and is not sharp as in the type species.

¹ *Op. cit.*

On the basis of the "perisquamosal," which Jaekel claims for *Diceratosaurus punctolineatus* Cope, the genus was regarded by that author as without a parallel among the known vertebrates. Such it would be if Jaekel's interpretations are correct but the morphology of the present skull would tend to throw grave doubt on the interpretation of this region of the skull as given for the type species. Another specimen representing another species also shows no evidences of the fusion of elements to form the "perisquamosal" and its presence in the type species is doubtful. So far as I can learn there has never been a true case of fusion in any of the cranial elements of the Stegocephala unless it be between the frontals of *Diplocaulus magnicornis* Cope, and I think I can detect a median suture even here. It was on the basis of such fusions that Maggi has proposed to derive the interparietal of the primates from the epiotics of the stegocephalans.

The posterior outline of the skull in the present specimen is not well preserved and the outline as given may be slightly inaccurate. The indentation figured by Jaekel in the posterior border of the skull of the type form is not present in the species under discussion.

MEASUREMENTS OF THE SKULL OF *Diceratosaurus laevis* MOODIE

	mm
Length of skull along median suture.....	37
Length from muzzle to tip of horn.....	50
Width between tips of horns, estimated.....	40
Width of orbit.....	7
Length of orbit.....	10
Width of skull across the orbits.....	30
Interorbital width.....	6
Length of nostril.....	2
Width of nostril.....	1
Diameter of the pineal foramen less than.....	1

The specimen on which the species is based is from the Linton deposits of Ohio and forms a part of the collection of Dr. J. S. Newberry now in the American Museum. It is No. 102 of the American Museum Collection.

DICERATOSAURUS ROBUSTUS sp. nov.

(Fig. 15)

The present species is indicated by the left portion of a cranium representing a large individual. The characters of the skull are so

clearly marked that it seems worthy of description. The presence of horns as given in the restoration of the skull is based on the analogy with the other two species of this genus in both of which horns are present. The generic determination of the species is based on the large size of the postorbital which is essentially characteristic of the other species of *Diceratosaurus*.

The characters which distinguish the species from the others of the genus are the large postorbitals and the small parietals which are

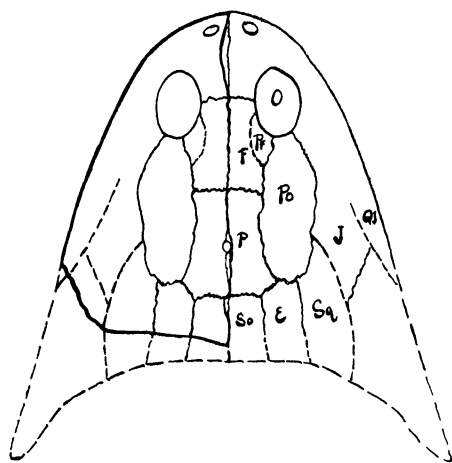


FIG. 15.—The skull of *Diceratosaurus robbustus*. E=epiotic; F=frontal; J=jugal; Pf=postfrontal; P=parietal; Po=postorbital; Qj=quadratojugal; So=supraoccipital; Sq=squamosal.

excluded from union with the postfrontals on account of the large size of the frontal. In the other two known species the frontal is small and the parietal comes forward to join the postfrontal. The present species exhibits a skull which is nearly twice as large as that of *D. laevis* and nearly three times the size of the skull of *D. punctolineatus*.

The portion of the skull preserved shows the cranium to have had a rather acuminate snout, not blunt as in the type species.

The orbit is an elongate oval although it has the same relative position in the skull as in the other species. The nostril is indicated by an oval depression near the anterior edge of the skull. The frontals as indicated by the sutures present on the portion of the skull preserved are fully as long as the parietals. Whether they were as wide as is represented in the drawing (Fig. 15) is uncertain. The postfrontals are represented by very small bones the sutures of which are somewhat uncertain although they cannot be far from what is represented in the drawing. The postorbital is large and elongate. It is distinctive of this species on account of its unusual size and of the genus as well,

although it does not attain such proportions in the other known forms. The parietals are elongate and narrow. The pineal foramen is represented by its lateral edge and its position is about midway of the longitudinal diameter of the parietals. The supraoccipital is represented by its anterior border. It is narrow. As restored it may be too long. The epiotic also is represented by an anterior portion and it shows this element to have the position and form which is typical of the form *D. laevis*. Such other of the cranial elements as are indicated are based on the relations discovered in *D. laevis*.

The heavy line on the left of the drawing represents the outline of the portion preserved. The skull, as restored, may be a little too long, and the shape of the horns is conjectural. In the orbit there are preserved two teeth showing longitudinal fluting. The longest tooth is about three millimeters.

MEASUREMENTS OF THE SKULL OF *Diceratosaurus robustus* MOODIE

	mm
Median length of the skull, estimated.....	67
Posterior width of the skull, estimated.....	78
Length of orbit.....	18
Width of orbit.....	12
Length of postorbital.....	27
Width of postorbital.....	14
Length of longest tooth.....	3
Width of same tooth at base.....	15

This specimen is from the coal mines of Linton, Ohio. It forms a part of the Newberry collection of the American Museum where it is No. 8,611 G.

ICHTHYERPETON SQUAMOSUM sp. nov.

The present species is based on well-preserved remains from the Linton, Ohio, beds. There are two specimens of the species preserved on blocks of bituminous coal and they represent the greater length of the animal. The species is located in the genus *Ichthyerpeton*, which was based by Huxley¹ on remains from the Coal-measures of Ireland (Fig. 16), on account of the character of the dermal covering which consists of small overlapping scales such as

¹ *Trans. Roy. Irish Acad.*, 1867, p. 351.

Huxley described for the form from Ireland. The specific characters of this form are the small size of the rounded scales, the attenuated tail, the apparent absence of limbs, the character of the ventral scutellation and the slightly curved condition of the ribs.

From the preserved remains it is estimated that the animal attained a length of not less than three feet and its body was long and slender and it may have had an appearance similar to that of a *Siren* or a *Proteus*. The slenderness of the body is a variance from the condition found in the type species, *Ichthyerpeton bradleyae* Huxley (Fig. 16)



FIG. 16.—The impression of *Ichthyerpeton bradleyae* Huxley. After Huxley.

in which the trunk was rather stoutly built. The character of the anterior portion of the body in the present species cannot be determined and the skull is wanting. There are no evidences of anterior limbs although the ventral scutellation preserved would seem to include the pectoral region. No pectoral shields are preserved nor are there any traces of pelvic elements or limbs.

The preserved portions on one block include nearly the entire tail and the posterior of the body and on the other block the dorsal region of the body and the anterior portion of the tail, so that the specimens supplement each other in an interesting manner. There are impressions of several vertebrae preserved. They are much of the same character as Huxley has described for the type species. They are short and thick and were probably amphicoelous. There are preserved the remains of rather slender recurved ribs mingled in with the

remains of the ventral scutellation and distinguished from the elements of the abdominal shield by their size and curvature. They were apparently single-headed, but the character of their articulation cannot be determined. The ventral scutellation consists of fine continuous rods arranged in the regular chevron pattern. They do not seem to be divided into oat-shaped scutes as is the case with the form described by Huxley. The ventral rods are closely packed for a distance of more than six inches but as they are scattered their exact arrangement cannot be determined. They seem to have extended to the cloacal region but there are no evidences of the specialized clasping organs such as are developed in the ventral armature of *Ophiderpeton*. The scales which are well preserved on the tail, may have covered the entire body since there are many scattered scales in the dorsal region of one of the specimens. The scales are slightly oval, tuberculate, and they measure scarcely one millimeter in their longest diameter. They show but slight evidences of having been imbricated though they may have been so although they may have been inclosed in the integument and somewhat separated from each other. The most posterior part of the tail preserved seems to indicate that the tip was attenuated. It was probably flattened from side to side. We may thus regard *Ichthyerpeton squamosum* as an elongate aquatic animal with a long flattened tail, and since there were possibly no limbs it would be an animal highly adapted for life in the water. The present species is of interest because it represents for the first time the discovery of the scaled Amphibia in the deposits of North America.

MEASUREMENT OF THE TYPES OF *Ichthyerpeton squamosum* MOODIE

Length of the animal as estimated from the two impressions.....	3 feet
Length of longest impression.....	21 inches
Length of specimen containing tail impression.....	9 inches
Width of tail impression, maximum.....	50 mm
Width of tail impression, minimum.....	6 mm
Width of a single scale.....	1 mm
Chevron rods in a distance of three mm.....	8
Distance from base of tail to the tip.....	125 mm
Width at base of tail.....	00

SECOND SPECIMEN

Length of specimen as preserved.....	225 mm
Width of chevron rod space.....	30 mm
Length of rib.....	25

The species is based on two specimens which form part of the Lacoe collection belonging to the U. S. National Museum where they are Nos. 4,476, and 4,459. The specimens are preserved on two blocks of bituminous coal from the mines at Linton, Ohio.

MACRERPETON HUXLEYI Cope

(Fig. 17)

The new genus *Macrerpeton* is proposed for the reception of the species of amphibian described by Cope as *Tuditonus huxleyi*.¹ This form he placed provisionally in the genus *Tuditonus* since it seemed to present the same type of sculpturing of the cranial elements similar to that found in *T. radiatus* Cope. Even this species, in all probability does not belong in this genus but it cannot be removed at present. Closer study of the type specimen of *Tuditonus huxleyi* Cope shows great variation from any of the species described from Linton, Ohio, and indeed from any Carboniferous form thus far known.

The specimen represents the left side of the face of a form which seems to approach the higher labyrinthodonts in the shape of the skull. The orbit is far removed from the border of the skull and taking the median line of the skull as somewhat further inward than the part preserved we have a skull which cannot be far from the figure (Fig. 17). The left posterior angle of the skull seems to be represented by a depression on the face of the block of coal on which the specimen reposes. The arrangement of the bones as given in the diagram (Fig. 17) strongly recalls that of *Capitosaurus* from the Keuper of Europe. The anterior border of the skull is restored after the skull of *Capitosaurus* but the skull may have been pointed as in *Archegosaurus*. The character of the teeth would seem to be such as to refer the form to a labyrinthodont. The teeth are very

¹ Rept. Ohio Geol. Surv., 1875, p. 397.

strong and curved backwards and they have the strong longitudinal fluting which is characteristic of many of the labyrinthodonts. Another character which would distinguish the form is the pattern of the cranial sculpture. This consists of inosculating pits and grooves

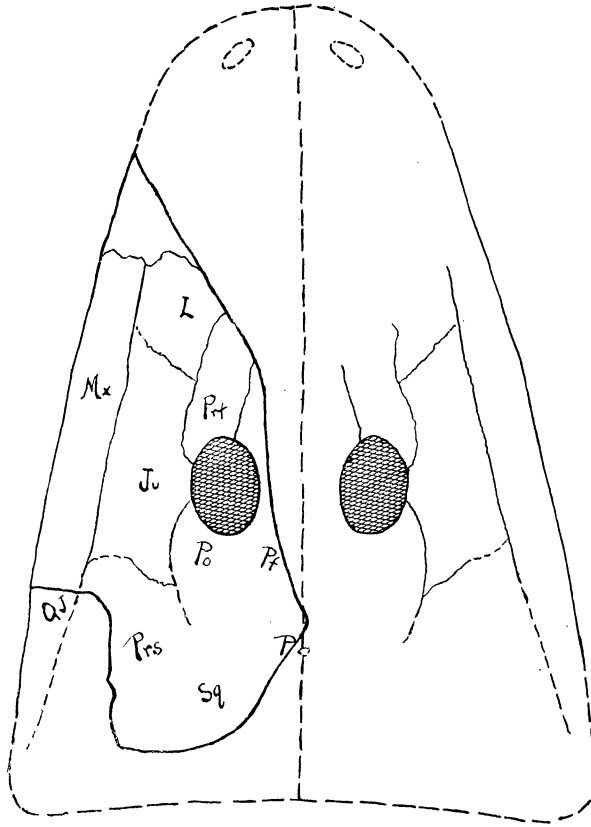


FIG. 17.—Restoration of the skull of *Macrerpeton huxleyi* Cope. One-half natural size.

of a coarse character and compares favorably with the sculpturing of the later forms like *Anaschisma* from the Trias of Wyoming. If this form really represents a labyrinthodont-like form it is the oldest of the kind so far known since in all probability the *Eosaurus* vertebrae come from a higher horizon. The specific characters have been given by Cope and further discussion will be deferred.

SAUROPLEURA LONGIDENTATA sp. nov.

(Figs. 18, 19)

This species may be distinguished from the other members of the genus by the large size and shape of the cranium and by the broad

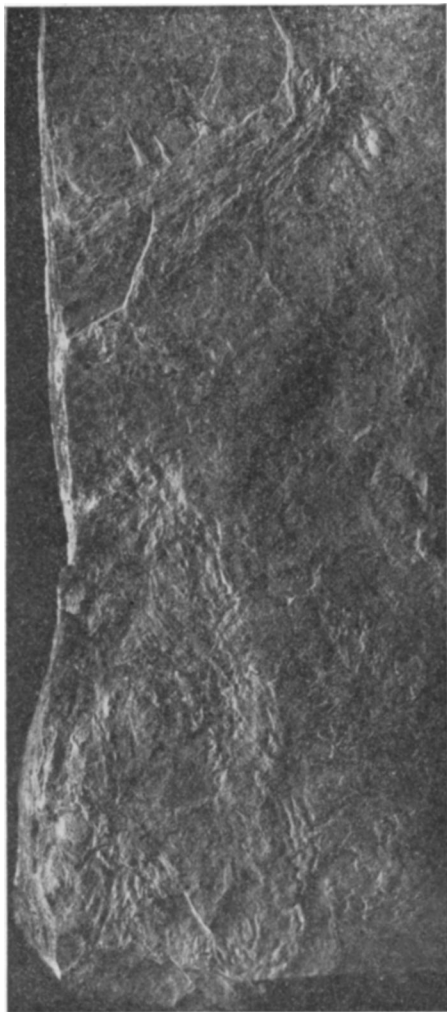


FIG. 18.—The type specimen of *Sauropleura longidentata*. Natural size.

mandible with its very long teeth. The skull of *Sauropleura digitata* Cope is not known but the body of that animal as preserved represents far too small a form for the skull to be referred to that species. The skull of the present species is fully half as long as the dorsal region of *S. digitata* Cope so that an association of the remains would be incongruous. From the skull of *S. scutellata* Newb. the present skull differs in size and proportions. The skull of *S. scutellata* is narrow while the skull of *S. longidentata* is quite broad. The teeth of the latter are characteristic of the species since in all of the other species of the genus where the skull is preserved the large anterior tooth is wanting.

Of the species *Sauropleura longidentata* there is preserved the right half of a cranium (Fig. 18) and the greater portion of the mandible belonging to the same individual. The bones

show the coarse sculpturing of the larger species of the Microsauria and it consists more of radiating grooves than of pits. The skull, as restored, is broadly ovate, with the posterior border truncate. The muzzle is broad and the nostrils are, apparently, located near the anterior margin. The pineal foramen cannot be detected. The posterior border of the orbits lies near the median transverse line of the skull. They are circular and are removed some distance from the margin of the cranium. Only the frontal and parietal can be

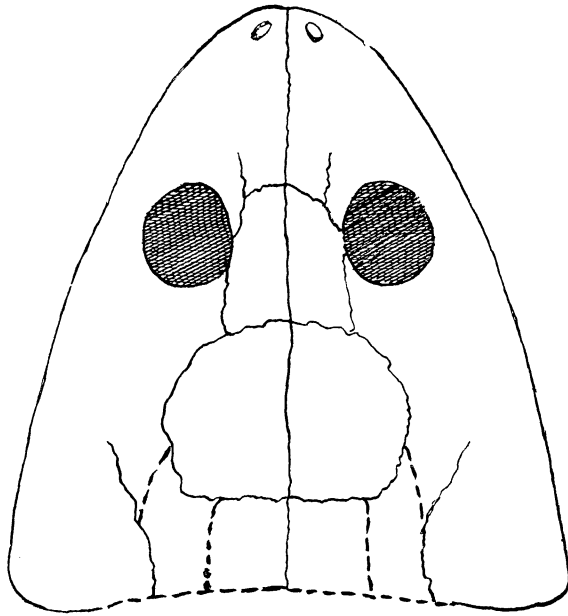


FIG. 19.—The cranium of *Sauropleura longidentata*. Natural size.

determined with certainty. These are seen to be rather large and have the usual relations of those elements.

The lower jaw is heavy and it is provided with heterodont teeth, which were possibly pleurodont, though this cannot be determined since the specimen lies on its inner side. Near the anterior end of the mandible there is a very long fang-like tooth, longitudinally striated, which rises from a broad base and rises to considerable prominence. It is slightly recurved. The other teeth are smaller though the next

succeeding one is still of considerable size. All of the teeth preserved are longitudinally striated but only the two anterior ones are recurved to any extent.

MEASUREMENTS OF THE TYPE OF *Sauropleura longidentata* MOODIE

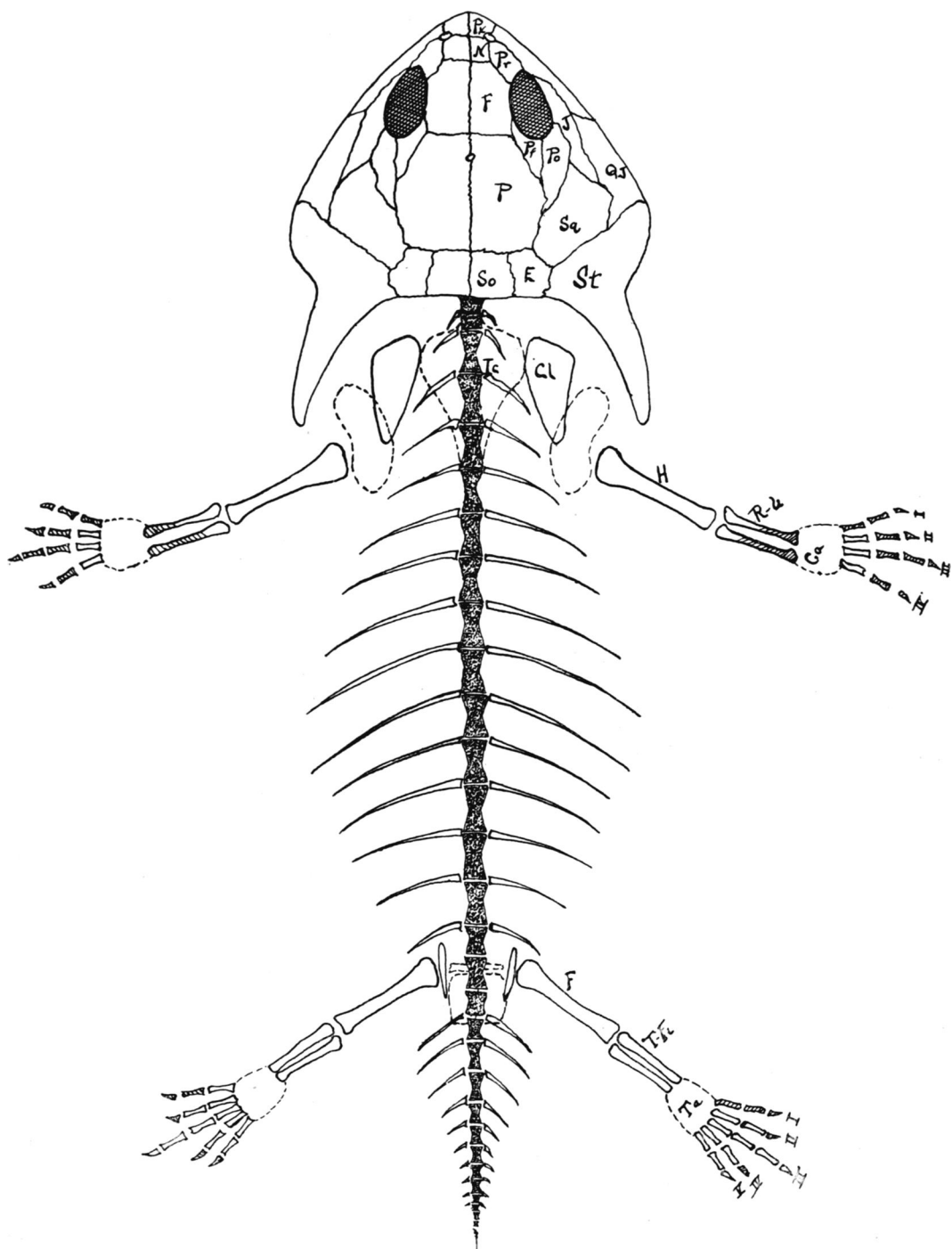
	mm
Length of the skull in median line.....	75
Width of skull at posterior border, estimated.....	80
Width of skull across orbits, estimated.....	60
Width of orbit.....	10.6
Length of orbit.....	12
Interorbital space.....	16
Length of jaw, as preserved.....	48
Width of jaw, maximum.....	16
Width of jaw, minimum.....	5
Length of longest tooth.....	11
Width of longest tooth at base.....	4.5
Length of shortest tooth.....	3
Width of shortest tooth at base.....	1

This specimen forms a part of the Newberry collection of the American Museum of Natural History where it is No. 8,619 G.

EOSERPETON TENUICORNE Cope gen. nov.

(Fig. 20)

The new genus *Eoserpeton* is erected for the reception of a single species originally described by Cope as *Ceraterpeton tenuicorne*. It cannot be placed under the genus *Ceraterpeton*, however, on account of the form and structure of the skull which varies widely from that of the type species of *Ceraterpeton*, *C. galvani* Huxley. The most important character in which the present species differs from *C. galvani* Huxley is the peculiar form taken by the prosquamosal as well as the fact that it is the epiotic which has the horn-like projection in *C. galvani* Huxley while in *Eoserpeton tenuicorne* Cope it is the supratemporal which bears the projection. The present species also lacks the projection at the side of the skull which is characteristic of the *Ceraterpeton*. No undoubted remains of the genus *Ceraterpeton* occur outside of England and Ireland, so far as I am aware. Fritsch referred a species, provisionally described as *Scincosaurus crassus*, to this genus but Andrews, Jaekel, and Woodward all agree that the species does not belong under *Ceraterpeton*. Jaekel even says there



20 —A restoration of the skeleton of *Eoscybelon tenuicorne* Cope. The lettering as in other figures. X:

are no horns in the species *Scincosaurus crassus* Fritsch. Cope described three species from the coal deposits of Ohio under *Ceraterpeton* but none of them belong there. Jaekel has defined one species so described, *C. punctolineatum* Cope, as *Diceratosaurus punctolineatus*

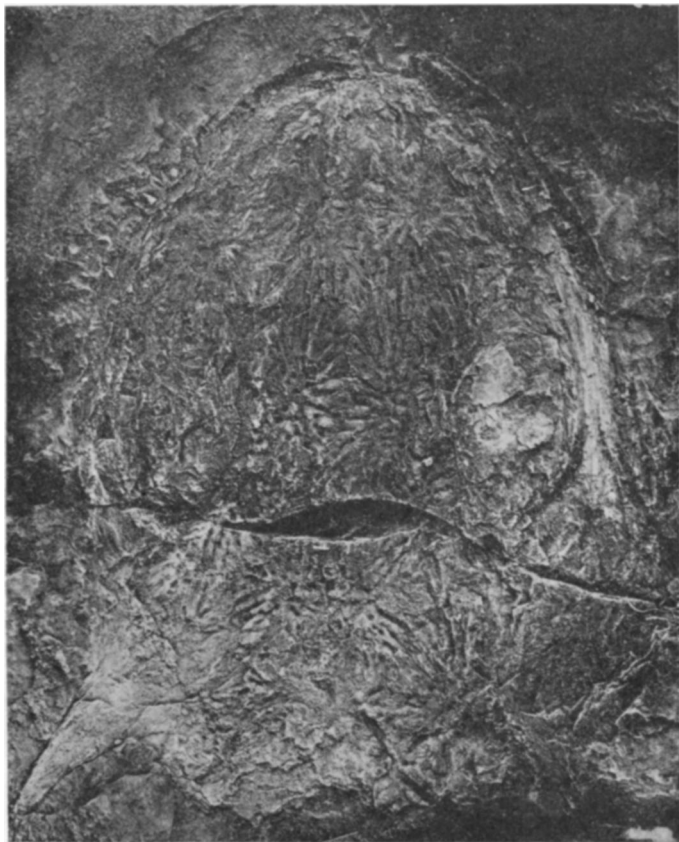


FIG. 21.—The impression of the skull of *Stegops divaricata* Cope. $\times 2$.

Cope and the other species is described here under the new genus *Eoserpeton*. The new genus is characterized from *Diceratosaurus* of Jaekel by the divergent character and shape of the horns, the shape and organization of the skull and by the form and position of the orbits.

The restoration of the species *Eoserpeton tenuicorne* Cope is based

on three specimens two of which represent the larger part of the animal and the other is a large skull in which the characters of the cranium have been detected. The two specimens in the National Museum at Washington (Nos. 4,472 and 4,473) are impressions of the same individual. It differs from the specimen in the horns being slightly incurved as represented in the drawing. This latter form was described by Cope in 1897.

STEGOPS DIVARICATA Cope gen. nov.

(Figs. 21, 22)

The genus *Stegops* has been erected for the reception of the peculiar form described below. This species was first described by Cope as *Ceraterpeton divaricatum*¹ but there are very good reasons why the form cannot be retained in this genus nor can it be placed in either the genus *Eoserpeton* or *Diceratosaurus*. The entire shape of the skull, the character of the horns and the presence of a large lachrymal are distinctive characters of the new genus *Stegops*.

The remains on which the new genus reposes consist of the impressions of a single well-preserved skull from the coal mines at Linton, Ohio. The chief characters which distinguish the genus will also serve to differentiate a new family of Microsauria which may be known as the STEGOPIDAE. The chief family characters are the large lachrymal unknown in any of the other species of Carboniferous Amphibia, the central position of the orbits, the general form of the skull, and the peculiar short divaricate horns. If an intertemporal element is present in the skull, which is suggested as a possibility, the family is further distinct.

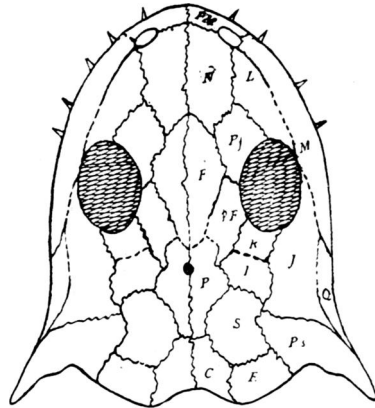


FIG. 22.—The outline of the cranial elements of *Stegops divaricata* Cope. The lettering as in other figures except I = intertemporal (?). $\times 1$.

¹ *Proc. Amer. Phil. Soc.*, 1885, p. 406.

SAURERPETON LATITHORAX Cope gen. nov.

(Fig. 23)

The new genus *Saurerpeton* is erected for the reception of the species described by Cope in 1897¹ as *Sauroplevura latithorax*. The characters which distinguish the genus not only from *Sauroplevura* but from all other known Microsauria are the broad plate-like character of the ventral scutellation, the broad rounded character of the pectoral plates, and the broad short skull. The structure (Fig. 23) of the skull

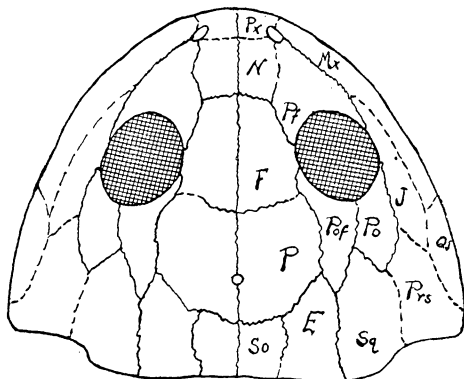


FIG. 23.—Outline of the cranial elements of *Saurerpeton latithorax* Cope. Less than natural size.

is nearest to that of the genus *Diceratosaurus* but the present form lacks the horns and the shape of the skull is also far different from that of the species of *Diceratosaurus*.

The skull of *Saurerpeton latithorax* Cope is broad and heavy. The teeth are heterodont. The body is broad and stout and the limbs are of unusually strong proportions. The ventral armature consists of broad imbricating scutes which form a single piece across the abdomen and are but slightly angulated to form the chevron. All other known Microsauria have the chevron armature strongly angulated and the scutes are usually long and slender. A distant approach to the condition of *Saurerpeton* is found in the *Ctenerpeton*, but the peculiar comb-like expansions and the shape of the body in the latter distinguish the two forms.

¹ *Proc. Amer. Phil. Soc.*, 1897, p. 86.

AMPHIBAMUS GRANDICEPS Cope

(Fig. 24)

This well-known species from the Mazon Creek deposits is restored herewith. The restoration is based on a specimen, nearly complete, in the collection of Mr. L. E. Daniels of LaPorte, Ind., and on the drawings of Cope.

In conclusion I wish to express my hearty appreciation to Drs. S. W. Williston and Stuart Weller for the interest they have taken in my work and for the help I have received from them.